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THIRD BIENNIAL REPORT
OF THE
COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the period from
October 1, 1900, to June 30, 1902.



MADISON
DEMOCRAT PRINTING COMPANY, STATE PRINTER
1902.



STATE OF WISCONSIN.

GEOLOGICAL AND NATURAL HISTORY SURVEY

BOARD OF COMMISSIONERS, 1903.

ROBERT M. LA FOLLETTE,
Governor of the State.

CHAS. P. CARY, VICE PRESIDENT,
State Superintendent of Public Instruction.

—, *President of the University of Wisconsin.*

EDWIN E. BRYANT, PRESIDENT,
President of the Commissioners of Fisheries.

JOHN J. DAVIS, SECRETARY.
*President of the Wisconsin Academy of Sciences,
Arts, and Letters.*

STAFF OF THE SURVEY.

E. A. BIRGE, DIRECTOR AND SUPERINTENDENT.

C. R. VAN HISE, CONSULTING GEOLOGIST.

T. C. CHAMBERLIN, CONSULTING GEOLOGIST.
Pleistocene Geology.

S. WEIDMAN, GEOLOGIST.
In charge of geology of Central Wisconsin.

L. S. SMITH, *In charge of Hydrography.*

U. S. GRANT, GEOLOGIST,
In charge of geology of Southwestern Wisconsin.

WARREN D. SMITH,
Field Assistant in Geology.

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THIRD BIENNIAL REPORT

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Covering the period from
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NORTH DAKOTA GEOLOGICAL SURVEY
UNIVERSITY, N. DAK.



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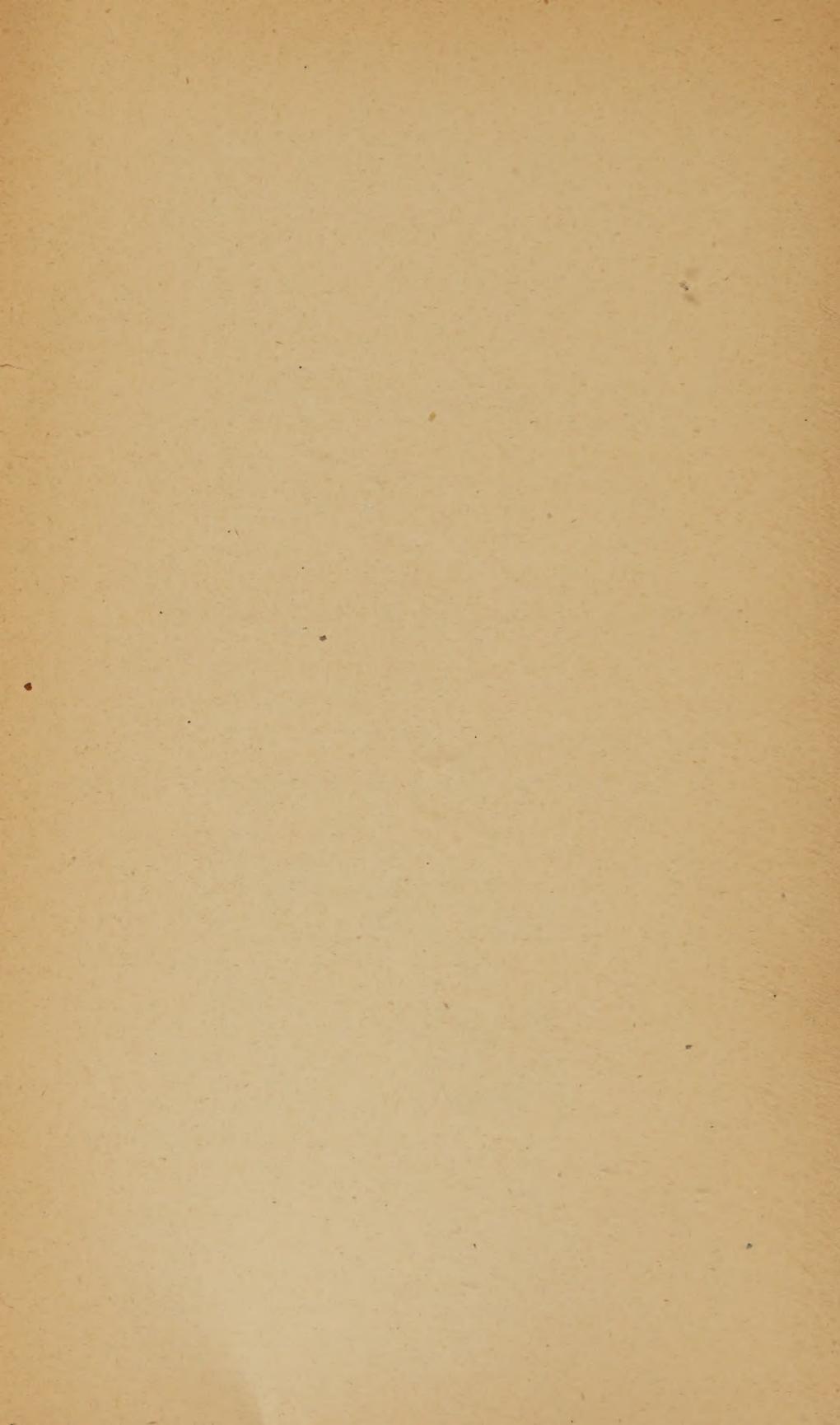


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STATE OF WISCONSIN.

GEOLOGICAL AND NATURAL HISTORY SURVEY

BOARD OF COMMISSIONERS.

ROBERT M. LA FOLLETTE,

Governor of the State.

L. D. HARVEY,

State Superintendent of Public Instruction.

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President of the University of Wisconsin.

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Vice-President.

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Secretary.

JAMES O. DAVIDSON, STATE TREASURER,

Treasurer.

June 30, 1902.

* Resigned October 11, 1901.

STAFF OF THE SURVEY.

E. A. BIRGE, Ph. D., Sc. D.,
Director and Superintendent.

C. R. VAN HISE, Ph. D.,
Consulting Geologist.

T. C. CHAMBERLIN, Ph. D., LL. D.,
Consulting Geologist. Pleistocene Geology.

E. R. BUCKLEY, Ph. D.,
Assistant Superintendent. Economic Geology.
Resigned September, 1901.

SAMUEL WEIDMAN, Ph. D.,
Geologist. Geology of Central Wisconsin.

CHANCEY JUDAY, A. M.,
Assistant Biologist until July 1, 1901.

L. S. SMITH, C. E.,
In Charge of Hydrography.

U. S. GRANT, Ph. D.,
Geologist. Professor of Geology, Northwestern University. In Charge of Survey of Copper-bearing Rocks, and Southwestern Wisconsin.

N. M. FENNEMAN, Ph. D.,
Geologist. Physical Geography of the Lake District.

WARREN D. SMITH, B. S.,
Field Assistant, 1902. Geology of Central Wisconsin.

Special assistants are also employed in the work of the Survey. Among these are: C. Dwight Marsh, Professor of Biology, Ripon College (Lake Biology); L. S. Cheney, Assistant Professor of Botany, University of Wisconsin (Forest Trees).

LETTER OF TRANSMITTAL.

HONORABLE ROBERT M. LA FOLLETTE,
Governor of Wisconsin.

SIR: I have the honor to transmit herewith the report of Dr. E. A. Birge, the Director and Superintendent of the Geological and Natural History Survey, for the past two years, and earnestly invite your attention to the same and to the recommendations therein.

The legislature of 1901 reduced the annual appropriation for the Survey to \$5,000, which is inadequate to the needs of the State in carrying on even the most important lines of investigation. Through the able direction of Dr. Birge, and the assistance of the eminent geologists, Professors Van Hise and Chamberlin, and the efficient associates employed in the work, as much has been accomplished as practicable, and the bulletins published during the biennial period and the reports now in the hands of the printer contain much valuable information. The report of Dr. Buckley on road materials, and the preliminary report of Professor Grant upon the survey of the lead and zinc region, are of vital interest to the State.

The Commissioners are united in urging the necessity of a permanent appropriation of not less than \$10,000 per annum to enable the investigations committed to their charge to be carried on.

Respectfully submitted,
EDWIN E. BRYANT,
President of the Board of Commissioners.

REPORT OF THE SUPERINTENDENT OF THE SURVEY.

To the Commissioners of the Geological and Natural History Survey.

GENTLEMEN: I submit herewith my report as Director of the Survey under your charge, from October 1, 1900, to June 30, 1902. I include also a statement of the work of the Survey during the summer of 1902; thus carrying the report up to the time when it goes to press. At the date with which the report begins the income of the Survey was \$10,000 annually; the legislature of 1899 having granted an appropriation of \$10,000 annually for two years in place of the former appropriation of \$5,000 annually for the same period of time. The legislature of 1901 reduced the appropriation to \$5,000 annually, but made it permanent. During the first part of the period covered by this report, therefore, the Survey had a larger income than it has received since, and this fact accounts for various matters to which I shall refer later.

I. PERSONNEL OF THE SURVEY.

The following persons have been employed by the Survey during the past two years, with the compensation stated in each case. All persons paid by the year or month have been allowed their actual expenses while in the field, in addition to the compensation stated.

E. A. Birge, Director and Superintendent of the Survey. At the date when this report begins, the Director was receiving a salary of \$500 per annum. After the reduction in the income of the Survey, the compensation was reduced to \$250 annually. No money has hitherto been paid to him on account of services rendered during the biennial term.

C. R. Van Hise, Consulting Geologist, without compensation, except field expenses.

T. C. Chamberlin, Consulting Geologist, without compensation, except field expenses.

E. R. Buckley, in charge of economic geology; salary \$1400 per annum. Dr. Buckley acted as Assistant Superintendent, October 30, 1900—May 1, 1901, receiving for the six months' service an additional compensation of \$200. In September, 1901, he resigned to accept the position of State Geologist of Missouri.

After his resignation he continued in charge of the report on road material, which has been completed and is now (December, 1902) in the hands of the printer.

Samuel Weidman, Assistant Geologist, in charge of areal geology; \$1200 per annum to May 1, 1901; \$1400 per annum thereafter.

U. S. Grant, Assistant Geologist; \$125 per month while actually employed. Professor Grant was engaged in the survey of the lead and zinc region during the summer and autumn of 1902. He has presented a preliminary report on the geology of the region, with reference to the mining industry.

Chancey Juday, Assistant Biologist; \$800 per annum, July 1, 1900—July 1, 1901. Employed on biological survey of lakes.

N. M. Fenneman, Assistant Geologist, physical geography of the lakes of Eastern Wisconsin; \$100 per month while employed; engaged during part of the summer and autumn of 1901 and 1902.

L. S. Smith, in charge of hydrography; \$5 per day while actually employed.

C. Dwight Marsh, Biologist; no compensation beyond expenses.

W. D. Smith, Field Assistant to Dr. Weidman during the summer of 1902; \$40 per month while actually employed.

Besides the persons named above others have been employed for special services and for short periods. Chemical analyses have been made by W. W. Daniells and Victor Lenher; Miss Florence Denniston has prepared illustrations for Professor Cheney's report on forest trees; and other persons have been employed in various temporary capacities. The names of all persons who have received money from the Survey, with the amount paid in each case, appear in the statement of expenses from the Secretary of State, which is appended to this report.

II. FINANCIAL STATEMENT.

Appended to this report is a statement from the Secretary of State, giving the names of all persons who have received money from the Survey, with the amounts received by each. In the case of those persons employed by the year or the month the sums paid include not only salaries but also expenses while in the field. In the following table I have summarized the expenditures of the Survey, not according to the persons to whom the money was paid, but by departments. The result is as follows:

	OCT. 1, 1900— SEPT. 30, 1901	OCT. 1, 1901— JUNE 30, 1902	TOTAL.
Administration.....	\$ 778 33	\$ 327 14	\$ 1,105 47
Clays.....	2,770 30	61 95	2,832 25
Building Stone.....	10 02	1 99	12 01
Road Material.....	155 31	145 51	300 82
Areal Geology.....	1,794 24	1,445 15	3,239 39
Lake Biology.....	1,390 68	37 74	1,428 40
Lake Survey.....	738 51	133 03	871 54
Physical Geography.....	58 35	58 35
North Wisconsin.....	408 53	9 34	417 87
Forest Trees (Drawings).....	118 67	153 00	271 67
Miscellaneous Analyses, etc.....	5 05	22 50	27 55
Total.....	\$8,227 87	\$2,337 35	\$10,565 32

Under the expenditures for clays is included a considerable number of items which more properly belong to road materials. Both of these subjects were in charge of Dr. Buckley and, until the clay bulletin was issued, all of his salary was charged to clays and the same was done with all expenses which were not directly chargeable to road material. In this way, the cost of the report on clays appears larger and that on road materials smaller than would have been the case had it been possible more accurately to separate the items of expenditure. The largest items in the expenditures for administration include \$325, paid for salaries to the director and to Dr. Buckley; clerk and janitor services \$231.85; express and freight (mainly for sending out bulletins), \$247.73; furniture and fittings, \$107.55. The balance on hand October 1, 1900, was \$4,374.88. The receipts from appropriations for two years were \$10,000; and the balance July 1, 1902, \$3,809.55. These sums do not agree exactly with the totals derived from the tables furnished by the Secretary of State. The figures here given refer to claims audited at my office during the period covered by the report and since

several days may pass before claims sent to the office of the Secretary of State are there audited, it always happens that his report includes certain bills which are not included in mine and excludes others which are reported by me. The Secretary of State also includes in his account, items paid from the general fund for printing and engraving.

The balance on hand July 1 will be expended, with the exception of a small amount, before Jan. 1. The largest items of expense from July 1 to Dec. 1 are as follows: Areal Geology, \$1,472.94; Geology of Lead and Zinc Region, \$649.79; Road Materials, \$500.00.

III. WORK OF THE SURVEY.

The reduction in the income of the Survey by the legislature of 1901 necessarily affected its work during the period covered by this report. Its investigations had been planned for an income of \$10,000 and were being conducted on that basis. The reduction of the income to half that sum made it imperatively necessary suddenly to break off lines of investigation which were in full progress but from which no complete results had been realized. This is especially true of the work in biology. Mr. Juday had but fairly begun his studies on the lakes when his work was stopped and the results from his very faithful and skilful service of a year are comparatively small. His material, however, remains, and the work can be resumed in the future if it appears advisable to do so.

The Survey has been unable to undertake much in the way of new investigations during this period. Its work has been mainly concentrated on the completion of Dr. Weidman's work on the geology of Central Wisconsin; on Professor Fenneman's report on the physical geography of the lakes; and on Dr. Buckley's report on road materials. The only important investigation which the Survey has commenced is the study of the lead and zinc region of Southwestern Wisconsin, of which a reconnaissance was made by Professor Grant during the summer of 1902.

The work in detail may be reported as follows:

A. Professor Van Hise has continued to render, without compensation, the same careful superintendence of the geological work of the Survey as in past years. He has given much time to supervising the investigations of Dr. Weidman and

Professor Grant, making several trips into the field with each of them. Besides these services, he has always been ready to advise with the Director on all questions relating to the welfare of the Survey and to advance its interests in all possible ways.

The Survey is under similar obligations to Professor T. C. Chamberlin, Director of the former Geological Survey and now Professor of Geology in the University of Chicago, for superintendence of the work in Pleistocene Geology. He has given much time and attention to advising with Dr. Weidman on the investigation of the glacial area of Central Wisconsin, and has more than once visited this field in company with Dr. Weidman. His services have also been given without compensation beyond the repayment of actual expenses while in the field.

B. Economic Geology. The work of this department was in charge of Dr. E. R. Buckley until he assumed the duties of State Geologist of Missouri in the fall of 1901. Since that time he has completed his report on road materials.

The Clays of Wisconsin. During the winter of 1901 the first part of the report on the clays and clay industries of the state was published in a volume of 304 pages, illustrated by 55 plates. This report contains a full account of the clay deposits of Wisconsin, with many analyses and complete information regarding the manufacture of clay products as at present carried on in the state. A large number of chemical analyses were made for this report by Mr. S. V. Peppel, whose work was completed in October, 1900. The reduction of the income of the Survey made it impossible to carry on investigations on the physical nature of the clays, including the study of their fusibility, shrinkage, etc. Nor has it been possible to make any study of possible materials for the manufacture of Portland cement. A large amount of careful scientific investigation will be required if this work is to be completed and the second part of the report published. Dr. Buckley's report has been received with much favor, both in this country and in Europe.

Road Materials and Road Construction. During the summer of 1901 Dr. Buckley completed the field work necessary to the preparation of his report on road materials. Data have been collected on the materials used in street and road construction and the methods of construction in all parts of the state, including the cost of construction, maintenance, and cleaning. Maps of each of the cities of the state have been pre-

pared, showing the kinds and amount of paving, or other improved road construction at the time of the date of the report. Careful tests have been made on the road materials used in the state for paving and macadam by means of an abrading machine, and an impact testing machine has been used with which to make tests of the cementing qualities of different stones used for the construction of macadam streets. The results of all this investigation will soon be published in a volume of about 300 pages, illustrated with 105 plates. This report is now in type and should appear early in the year 1903.

The illustrations in this volume have nearly all been collected in Wisconsin. The cross sections and other drawings of pavements have mainly been copied from blue prints of drawings actually used in the construction of pavements in Wisconsin.

In the introduction Dr. Buckley says, "Up to the present time, highways in Wisconsin have meant simply narrow tracts of land connecting different parts of the country. The highest conception of the public thoroughfare in many parts of the state has been its maintenance in a passable condition. Any economy which might be involved in the construction of permanent pavements has been given very little attention by the people and much less by the state legislature. Up to within a few years ago, little or no attempt had been made to educate the people in the principles of road construction and maintenance." * * * * "The one idea in road construction, as exemplified by the work of the roadmaster, has been to fill the gullies and level off the roadway with such material as might be closest at hand."

"The cities, towns and villages are the places to which the country must look for practical demonstrations in the science of road construction." * * * * "The improvement of the city and town streets naturally precedes that of the country highway and it may be some years before the country roads are to any extent permanently improved."

Chapter I takes up a discussion of the various parts to the highway and makes two classifications of highways based upon ownership and traffic conditions. The agents which destroy the pavement are also considered. Natural and artificial causes both contribute to the ultimate decay of all pavements.

Chapter II is a discussion of the materials used in improving highways. The materials entering into street construc-

tions are considered as natural and artificial, and include sand clay, gravel, wooden blocks, stone, cement, coal tar, asphalt, gumbo, brick, oil, cinders, slag, iron pipe, vitrified sewer pipe, cement pipe, drain tile, glass, charcoal and asphalt blocks. The author says, "Each of these has its own peculiar characteristics which best fits it for use in different parts of the various pavements." Each of these materials is then taken up in alphabetical order and considered with reference to its suitability for use in street constructions.

In Chapter III the methods of constructing different kinds of pavements are considered.

Chapter IV is a discussion of drainage. Underground and surface drainage are both discussed in detail with reference to the different kinds of pavements.

Chapter V considers primarily the different pavements which have been constructed in Wisconsin cities. The different counties in the state are considered separately and in alphabetical order with reference primarily to the road metals available in the county. The cities, and towns in which permanent road improvements have been made are then considered. The method of constructing the pavement, the kind of materials used, and the subsoil conditions are all considered and recommendations as to improvements are frequently made. This portion of the report ought to be especially valuable to cities, towns and villages that expect to pave their streets and desire to make inspection tours before settling on the kind of pavement to construct.

Chapter VI is a discussion on the tests on road metal made in the Survey laboratory.

In Chapter VII the author discusses the subject of street pavements and their maintenance in general, making recommendations as to methods of caring for macadam, asphalt and other kinds of pavements,

C. Areal Geology. The geological report and map of north-central Wisconsin which was begun when the Survey was first organized is now nearly ready as a whole for the press. A part of the report, that relating to the soils and agricultural conditions, is now in press, being printed as a bulletin of the Survey and also as a part of the annual report of the State Board of Agriculture for 1902.

Area Surveyed. The area surveyed includes Portage, Wood, Clark, Marathon, Lincoln, and Taylor counties, with adjoining

parts of Langlade, Price, and Gates counties. The surveyed area is the shaded portion shown on the accompanying sketch map of Wisconsin. The area comprises 199 townships, with an approximate extent of 7,200 square miles, which is about one-eighth the area of the state. The area is considerably larger than that of Connecticut and a little less than that of New Jersey.



It was originally planned to survey and report upon a much smaller area than this, about 3,000 square miles in the vicinity of Wausau, but on account of the complex character of the crystalline geology it was necessary to cover a larger area and examine a larger number of rock exposures in order to work out the true relations of the various formations. It was originally planned also to report only upon the crystalline rocks of the area, but this plan has been enlarged and made to include a re-

port of all the geological formations of the area, which are, besides the crystalline rocks, the formation of Potsdam sandstone and the various glacial drifts. The soil map and soil report, which it is believed will be of great practical value to those interested in the agriculture of this part of the state, is also a direct outcome of the enlarged plan and is based upon information collected in connection with the survey of the glacial drifts and other surface formations of the area.

It may be noted by referring to the former biennial reports of the Commissioners of the Survey, that during the first two years, 1897 and 1898, about 2,500 square miles in the vicinity of Wausau and Marathon were surveyed, and that during the second two years, 1899 and 1900, an additional area of 1,500 square miles were surveyed in the vicinity of Medford, Marshfield, and Grand Rapids. During the past two years, 1901 and 1902, 3,000 square miles additional were covered in the vicinity of Stevens Point in Portage county and in western Clark, western Taylor, and southern Price counties. The larger area covered during the past two years, as compared with the former two-year periods, is principally due to three causes: the larger acquaintance and fuller knowledge of the geology of the area; the more simple character of the formations prevailing in Portage and Clark counties; and the help of a field assistant, Mr. W. D. Smith, during the present season of 1902.

Nature of the Report. The report of the area of 7,200 square miles in north-central Wisconsin will contain a description of the geology, economic geology, physical geology, the soils, and colored geological and soil maps.

Geology. The description of the geology will constitute about one-half the report, and is necessarily written from the scientific standpoint. The geological formations of the area range from the most ancient crystalline formations known in geology to the newest glacial deposits. The crystalline formations include all the groups of igneous and also such metamorphic sedimentary rocks as quartzite, slate, and conglomerate. In carrying on the work of the survey every ledge of rock was examined, located on the section map, and specimens collected for study under the microscope or by chemical analysis. It is among the metamorphic sedimentary rocks that iron ores are likely to occur. In mapping the geological formations a number of occurrences of banded slate, the formation closely associated with the iron ores of the Lake Superior region, were

ound; While these occurrences of banded slate led to no discovery of iron ore in this area, their presence here is at least encouraging and seem to indicate the probability of other areas of slate and possibly of some iron ore in the unmapped portion of the State farther north.

The glacial drift of the area includes the deposits of drift of several distinct and widely separated glacial periods. In all, four drift formations, and possibly five, have been distinguished and mapped. While the mapping of the various drifts may at first sight appear to be of scientific interest only, it really has a great practical value, for the age and character of the drift directly controls the soil and agricultural conditions of the area.

Economic Geology. The economic geology includes the description and location of the various rock products of the area which have, or may have, an economic value. This includes granite rock used for cemetery and building purposes, the sandstones used for building purposes, the deposits of quartz rock used as an abrasive and for other purposes, the various crystalline rocks suited for road material, the brick clays, the marl and peat deposits, and the water supply.

Physical Geography. The physical geography of the area includes the description of the various land forms of the area and the history of their development. The relative ages of the various topographical features, such as the plains, valleys, and hills, are discussed; and the changes in the river courses and their causes are described. The description of physical geography of the area, it is believed, will be of great value to the schools of the area.

Soils. The general report and map of the soils describes the various soils of the area, and the area occupied by each is shown on a colored map. The soils of the area are described with respect to their area, surface features, character and origin, ground water, forest growth, and crops. A brief discussion of the climate and rainfall, and conditions of agriculture in the area is also presented.

D. Investigations of the Lakes. Only a small amount of work has been done during the past two years on the inland lakes of the state, but a report on their physical geography has been completed. As stated in the last biennial report, the work falls under three heads:

Hydrographic Survey. Very little work has been done in this department during the biennial period. Maps of Big Cedar Lake and Lake Monona have been published, the field work for which was completed at an earlier date. The survey of Lakes Waubesa and Kegonsa has been finished and the maps have been drawn, but have not been printed. A portion of the maps which have been published hitherto have been bound in manilla covers and issued in separate form. It is proposed to arrange the entire series, including Lakes Waubesa and Kegonsa, in an atlas which will be published to accompany the report of Professor Fenneman.

Physical Geography. Professor N. M. Fenneman has completed his study of the physical geography of the lakes and his report is now (Dec. 1) in the hands of the binder. It is contained in a volume of 178 pages, illustrated by 36 plates. The report is intended to assist students of physiography, and especially the teachers of Wisconsin, in using the natural features of the state as an aid to understanding the principles of physical geography and geology. This bulletin belongs to the educational series and continues in another field the kind of work done by Professor Salisbury and Mr. Atwood for the region of Devil's Lake and the Dalles. In that report were discussed the forces which have produced the scenery of the district. In Professor Fenneman's bulletin attention is directed to the origin and history of the small lakes so abundant in Southeastern Wisconsin, and the work done by them on their shores is discussed in detail. It is expected that the report will be used as a guide to students and teachers who visit the lakes, either to study their physiography or to demonstrate to others the part which lakes play in the forces which modify the landscape. The report consists of 10 chapters, of which the first two are devoted to general description, dealing with the geology of the area, the origin and extinction of the lakes, and to the work of lakes on their shores. The remaining chapters take up in detail the physical geography of the several groups of lakes, including the Madison lakes, Lakes Geneva, Delavan, Lauderdale and Beulah, the Oconomowoe lake district, the lakes of Washington county, Elkhart Lake, Green Lake, and Waupaca Chain of Lakes.

Lake Biology. As already indicated, comparatively little has been accomplished in this department. It has been practically impossible for the director to complete any of his scientific

studies, owing to the pressure of duties as Acting President of the University. Mr. Juday's work was, in great part, left incomplete when he resigned in July, 1901, but he has since submitted a brief report on the night and day movements of the smaller crustacea of the lakes. The Survey was able to grant only small sums of money to Professor Marsh during the past two summers, but he has in progress and nearly completed a report on certain features of the animal and vegetable life of the open water of some of the lakes of central Wisconsin, especially Lake Winnebago and Green Lake. Most of the field work for this report was completed in the summers of 1899 and 1900. This paper with Mr. Juday's report mentioned above will probably be issued together as a bulletin.

E. *Copper-bearing rocks of North Wisconsin.* In my last biennial report an account was given of Professor Grant's field work in this region. As there indicated, he prepared an additional chapter for the second edition of his report, dealing with these formations in Washburn and Bayfield counties. This edition was issued in the spring of 1901 and has been distributed. The report in its final form contains 83 pages and is illustrated by seven plates and six maps. The additional investigation revealed the same state of facts with regard to copper as that shown by the earlier work, namely: the presence of copper in small quantities over a wide area and its presence in a few localities in quantities which warranted commercial exploration. So far as reported, however, no valuable deposits of copper have yet been found in this region.

F. *Investigation of the Lead and Zinc Region.* During the past two years there has been a revival in mining lead and zinc in Grant, Lafayette, and Iowa counties in the southwestern portion of the state, Professor Grant most of July, August, and September, 1902; in this district, examining the different mines and the general geological features. The object of his work was the preparation of a preliminary report on the lead and zinc deposits of the state. The results of the work have been very encouraging and there is good reason to believe that this district will continue to produce increasing quantities of lead and zinc. The mines thus far opened have been located on some of the earlier workings from which large quantities of lead had been obtained. These mines have demonstrated that, at least in many cases, below these older lead workings there exist important deposits of both lead and zinc. A preliminary

report on this district has been prepared and is in the printer's hands. It will contain an account of the mining industry and general geology of the district, with some statements concerning the future prospects of mining and the needs of the district. During part of the field season Mr. Edwin E. Ellis, of Northwestern University, acted as assistant to Professor Grant.

IV. PUBLICATIONS.

During the period covered by this report, two bulletins have been issued, both of them belonging to the economic series. Their titles are as follows:

Bulletin No. VI. Economic Series No. 3. Preliminary report on the Copper bearing Rocks of Douglas County, Wisconsin. Second Edition. Containing a preliminary report on the copper-bearing rocks of Washburn and Bayfield Counties. U. S. Grant, Professor of Geology in Northwestern University. Pp. VIII, 83; 13 plates, of which 6 are maps and one figure in the text.

Bulletin No. VII. Part I. Economic Series No. 4. The Clays and Clay Industries of Wisconsin. E. R. Buckley, Assistant Superintendent, Wisconsin Geological and Natural History Survey. Pp. XII, 304; 55 plates.

Both of these bulletins were issued in the spring of 1901. An account of these bulletins has been given under the appropriate head in the preceding section of the report.

In May, 1902, there was published a five page circular, with a map, relating to certain large deposits of feldspar near Wausau. These deposits were sufficiently promising to warrant commercial investigation and an edition of 200 copies was printed of this report. It was distributed mainly in the locality concerned and to the newspapers of the state.

Two hydrographic maps have been issued:

No. 9. Big Cedar Lake, Washington County. Scale three inches to the mile.

No. 10. Lake Monona. Scale four inches to the mile.

These maps are issued in the same style as those published earlier and described in the report for 1898-1900.

The interruption of the investigations of the Survey consequent on the reduction of its appropriation two years ago greatly delayed the preparation of further publications, and no

further bulletins were printed before June 30, 1902. Work was continued on several publications and four are now (Dec., 1902) in process of publication. These are as follows:

Bulletin No. VIII, Educational Series No. 2. The Lakes of Southeastern Wisconsin. N. M. Fenneman, Professor of Geology, University of Colorado. Pp. IV, 178; 36 plates; 36 figures in the text. This bulletin is already printed and will be distributed before the appearance of this report.

Bulletin No. IX. Economic Series No. 5. Preliminary Report on the Geology of the Lead and Zinc Region of Southwestern Wisconsin. U. S. Grant, Professor of Geology, Northwestern University. This bulletin is now ready for the printer and the map is in process of engraving. It will contain about 80 pages of text. Its contents are summarized on page 20 of this report.

Bulletin No. X. Economic Series No. 6. The Roads and Road Materials of Wisconsin. E. R. Buckley, state geologist of Missouri. The engravings and maps for this bulletin are already printed and the manuscript is in the hands of the stateprinter. The report will make a volume of about 300 pages, with 106 plates and maps. An account of its contents is given on pages 13 to 15.

Bulletin No. XI. The Soils and Agricultural Conditions of North-central Wisconsin. S. Weidman. An account of this bulletin has been given on page 18.

V. PLANS FOR FUTURE WORK.

This Survey was established by chapter 297 of the laws of 1897, and the first duty assigned to it by that statute was the completion of the geological survey of the state, in both its scientific and economic aspects. To this work the Survey has devoted by far the larger portion of the appropriations hitherto made by the legislature. In completing the geological map of the state, the Survey committed to Dr. Weidman the working out of the difficult problems offered by the great area of crystalline rocks in the center of the state. The investigation began in Marathon County and has extended into parts of the adjacent counties. An area of about 7,200 square miles has been carefully examined. Upon this area Dr. Weidman is now ready

to report; the geological map is in process of engraving; and the reports will soon be ready. The Survey ought to continue and extend this work until the entire area of crystalline rocks found in the state, including some 25,000 square miles, has been adequately studied. This, however, will be a task covering a considerable number of years. The policy which the Survey has followed, of carrying on the work with one geologist, aided perhaps by an assistant, rather than putting a large party into the field, seems to be the wisest course to pursue, in view of the size of the appropriations which we are likely to receive and the other claims upon the resources of the Survey.

Some of the most important problems in economic geology which are now presented by the state and those most in need of prompt investigation, are those connected with the lead and zinc region of Southwestern Wisconsin. The survey of this region made twenty-five years ago by the last Geological Survey is not at all adequate to the needs of the miners at the present day. A new survey should be made and must be pushed rapidly if practical results are to be reached, either proportional to the cost of the investigation or to the needs of the state. There should be published an accurate map of the entire southwestern part of the state, including Grant, Lafayette, and Iowa counties, and, if possible, some of the adjacent region. This map should be on a scale at least as large as one inch to the mile, and should show the cultural features, such as roads, railroads, buildings, etc.; water features; topography by contour lines, contour interval, twenty or ten feet; geological formations; elevation of the bottom of the Galena limestone, by contour lines. The maps prepared by the U. S. Geological Survey of a part of this district are on too small a scale to serve as a basis for the map here proposed, and the work, except for triangulation and some leveling, must be done again.

In addition to the above, large scale maps of the important mining centers should be prepared. The character of such maps is described below. After the mapping is practically completed, a monographic account of the district should be printed,

The work above outlined could not be conveniently, nor economically, done in one year. A good start could be made on it, however. It seems advisable that the work should be begun by mapping on a large scale a few of the important districts, which are important not only from the mining standpoint, but also from the fact that in them could probably be

worked out some of the geological problems intimately connected with the genesis of the ore deposits. These maps should be made in the field on a scale of at least four inches to the mile and published on a scale not less than half of this. In addition to the features shown on the large map, these large scale maps should show the following: contour level, ten feet, allowing great detail of topography; all outcrops; mines, concentrating mills and old workings, the altitudes of the dividing lines between different formations in many places, by figures obtained by leveling, possibly the limits of other formations, in addition to the Galena limestone, by contour lines.

I would suggest that the following areas be mapped first: vicinity of Platteville, about 25 square miles; vicinity of Potosi, about 15 square miles; Hazel Green to Shullsburg, including Benton, New Diggings, etc., about 60, or more, square miles. During the coming summer the first two of these areas could be mapped and the maps published in the winter of 1903-4. A large part of the work on the third area could be done during the coming summer, and possibly the whole could be completed, in which case this map could be published with the others.

The work here outlined is of the same general character as that undertaken by the former Survey of Wisconsin, and will complete that work with the greater detail and accuracy demanded by present conditions. This report is greatly needed in the lead and zinc district and will, I think, be of more value to the people of that district than any other line of work the Survey could do there. The detail and accuracy of the work is in advance of that undertaken elsewhere in the state. But such accuracy is needed there and it will be useless to do more work in the district unless it is carried out in detail.

A third subject in which work should be carried on by the Survey is the completion of the investigation of the clays and clay industries. Dr. Buckley's report gives a sufficiently complete account of the geological and chemical relations of the clays. An equally important subject of investigation is their physical relations, and also the investigation of the question of the suitability of clays for the manufacture of Portland cement, paving brick, and other clay products of higher value. These investigations, if carried on, will necessarily be extensive and somewhat slow, since a great number of tests must be made. Unquestionably the clay products of the

state are certain to become more and more important economically, as the supply of timber decreases, and the investigation of the clays is a subject whose importance is great at the present time and increases from year to year.

Much the same statement can be made regarding the investigation of the road materials of the state. The report now in press gives a fairly complete account of the present condition of road construction in Wisconsin, with general advice and directions for the building of improved highways. The Survey, however, has not finished its duty toward roads by the publication of this report. It already possesses testing apparatus and should be able to maintain an investigator who should make tests of the road materials from all parts of the state, as these are brought into use, so that there may be accumulated complete information regarding all possible materials used in the state for the improvement of highways. These tests cannot be made at one time and published in a single report. The demand for information on such matters does not come in any one year, but requests for such information are received continually. There is abundance of work in this and allied directions to occupy the full time of an investigator, and the economic results to the State would far more than repay the cost of such a department of the Survey.

The Survey has been unable to carry on any investigations of the forests since the publication of the first bulletin of Mr. Roth, whose studies were made at the joint expense of the United States Department of Agriculture and of this Survey. No argument is needed to show that careful investigation of the regions of the state formerly occupied by forests is necessary, and that the economic results of a wisely directed investigation will be far greater than any possible cost of such a study. Unless the funds of the Survey, however, are greatly increased, it will not be practicable for us to extend the work in this direction.

There is still another line of investigation, not of the greatest importance, yet one which demands a certain amount of attention. This is the subject of peat. Wisconsin possesses very large areas of peat and the question of the utilization of this material for fuel is one which calls for careful study. There are many difficulties in the way of the successful use of peat, yet these will be overcome in the future and these deposits will be utilized. The Survey has already received numer-

ous requests for the investigation of marshes — requests which it has been unable to meet with the funds at its disposal. A general investigation of the more important deposits of peat in the state, together with analyses of the material, could be made at no very great cost. Such a report would furnish the kind of information which experimenters and those interested in the commercial utilization of peat would find necessary as the first condition of success in their undertakings.

I have always considered that the first claim on the funds of the Survey was for work in geology and that the other departments included in the Survey must be secondary to those of geology. I am unwilling, however, to devote all of the work of the Survey to geological investigations only, since in other directions work can be done of great use to the state. This is especially true with regard to the investigation of the inland lakes. No equal area of the State is a more valuable asset than that which is included in our inland lakes. The study of these bodies of water, both from the scientific and economic standpoint, is fully warranted by their pecuniary value to the community. As in all departments, scientific study must to a large extent precede the economic work, since the latter is necessarily based upon more purely scientific investigations. When the appropriation for the Survey was reduced, the work on the lakes was stopped, with the exception of the studies of Professor Fenneman which were already on their way toward completion. The Survey, however, should plan to devote small sums of money annually to this investigation, with the design of gradually bringing together a body of knowledge regarding these lakes which will enable the State, both in its public capacity, as represented in the Commissioners of Fisheries, and through private individuals, to treat these lakes in such a way as to secure the greatest results from them. There should ultimately be made a complete report on the lakes of the state in regard to their hydrography, physical geography, the chemistry of their waters, and their life. The Survey has made a beginning with regard to the first two steps named, in the publication of the hydrographic maps and Professor Fenneman's bulletin. The other subjects have as yet hardly been touched.

The account given of the work done by the Survey during the past and the list of its publications show that there is a large amount of investigation needed by the State, which

this Survey has already accomplished. I do not hesitate to invite a comparison of the work done by this Survey during the past five years with that accomplished by any other state survey, considering the amount of funds at its disposal. The publications of the Survey will be found to hold their own in comparison with others, both in scientific value and in practical value to the people of the State, and no survey is worthy of support whose publications fall short in either of these particulars. An investigation of the expenditures of the funds of the Survey will, I am confident, show that they have been administered economically and with the view of securing the best possible results for the state, scientific and practical.

It is obvious also from the statement of investigations not yet entered upon that the work to be done is far greater than that already accomplished, and that there is need of a permanent department of investigation along the lines covered by this Survey. It is plain also that no amount of work adequate to the needs of the state can be done on an annual appropriation of \$5,000. In order to prosecute even the most important of the lines of investigation now carried on and needed by the state, an annual appropriation of at least \$10,000 is necessary. I should request the Commissioners to ask from the legislature, if possible, an increase of the permanent appropriation to \$10,000 annually, so that the work of the Survey may be planned with a view to distributing the work over such time as is necessary to secure the best results in each of the lines of investigation pursued.

Respectfully submitted,

E. A. BIRGE,

Dec. 1, 1902.

Director and Superintendent.

FINANCIAL REPORT—FROM SECRETARY OF STATE—GEOLOGICAL SURVEY.

OCTOBER 1, 1900—SEPTEMBER 30, 1901.

<i>Geological and Natural History Survey:</i>		
Allyn, Abbie M.	\$181 97	
American Express Co.	62 77	
Buehler, H. A.	33 30	
Buckley, E. R.	1,886 33	
Bausch & Lomb Optical Co.	11 15	
Birge, E. A.	893 73	
Burns, John.	26 30	
Cheney, L. S.	118 67	
Curtis, N. P.	43 25	
Cowie, Harry.	9 75	
Cook, H. A.	22 80	
Democrat Printing Co.	2,006 21	
Dickman & McKenzie	20 00	
Dane Co. Telephone Co.	12 00	
Daniells, W. W.	44 00	
Doyon & Rayne Lumber Co.	22 81	
Fenneman, N. M.	521 39	
Ferris, W. S.	217 00	
Gay, Robert.	139 18	
Grant, U. S.	258 32	
Green, H. P.	18 00	
Gallagher Tent & Awning Co.	15 00	
Garvins, G. W.	11 60	
Hollister, A. H.	6 55	
Haumer, E. J.	18 40	
Juday, Chancy	893 97	
Lenher, Victor.	32 00	
Lorrigan, D. E.	45 40	
Marsh, C. Dwight	184 64	
Morris, T. S.	10 93	
M. Office and School Furniture Co.	27 61	
Nicholson, D. P.	15 00	
Northwestern Litho. Co.	1,322 33	
Ohm's, Fred C., Son.	107 40	
Owens, Wm.	19 50	
Peppel, S. V.	81 60	
Parr & Kroncke.	58 65	
Richter, E. S. & Son	21 50	
Savage, J. L.	45 00	
Sumner, E. & Son	14 00	
Sanford, Fannie G.	90 00	
Smith, Leonard G.	50 34	
Silvernagel, J. J.	8 00	
Smithsonian Institution	28 50	
Sargeant, E. H.	67 50	
Tyrrell, Joseph.	117 95	
United States Express Co.	25 45	
Van Hise, C. R.	45 98	
Weidman, Samuel	1,410 22	
		\$11,326 95

OCTOBER 1, 1901—JUNE 30, 1902.

<i>Geological and Natural History Survey:</i>		
American Express Co.	\$110 89	
Alexander, Walter	66 81	
Allen, R. C.	30 40	
Brietwisch, A. J.	20 00	
Birge, E. A.	198 56	
Bibbs, Idalyn	9 20	
Clark Engraving Co.	93	
Dennison, F. K.	60 00	
Democrat Printing Co.	244 58	
Eimer & Amend	8 25	
Fenneman, N. M.	299 28	
Heald, H. F.	11 85	
Hollister's Pharmacy	4 00	
Lenher, Victor	162 50	
Marsh, C. Dwight	17 20	
Ohm's, Fred C., Son	27 00	
Pickering, R. C.	3 75	
Sanford, F. G.	110 00	
Smithsonian Institution	48 40	
United States Express Co.	48 34	
Van Horn, F. B.	6 50	
Weidman, Samuel	1,204 48	
Yager, M. E.	23 25	
		\$2,716 17

STATUTES OF WISCONSIN RELATING TO THE GEOLOGICAL AND NATURAL HISTORY SURVEY.

CHAPTER 297, LAWS OF 1897.

An Act to provide for the investigation of the natural resources of the state of Wisconsin, and providing an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby constituted a geological and natural history survey of the state of Wisconsin.

SECTION 2. This survey shall have for its object:

(1) The completion of the geological survey of the state, and especially the examination of the rocks, with reference to the occurrence of iron ores, building stones, and other valuable mineral products, and in reference to their value as material for road construction.

(2) A study of the soils of the state.

(3) A study of the plants of the state, and especially of the forests, with reference to their cultivation and preservation.

(4) A study of the animal life of the state, and especially the occurrence, distribution, and production of fish in the lakes and streams of the state, and a study of foods and enemies of fish.

(5) The preparation of an account of the physical geography and natural history of the state, in such form as to serve as manuals for the public schools, and of special reports on subjects of economic importance, in such form as to be of direct service to the people.

(6) The completion of the topographic map of the state begun by the United States Geological Survey; but no money shall be expended for topography unless an equivalent amount be expended for this purpose in the state by the United States government.

SECTION 3. This survey shall be governed by a board of commissioners, consisting of the governor of the state, the state superintendent of public instruction, the president of the state university, the president of the commissioners of fisheries, and the president of the Wisconsin Academy of Sciences, Arts and Letters. The commissioners shall meet within thirty days after the passage of this act, and organize as a commission and adopt by-laws for their government, not inconsistent with law, and shall meet at such time and places as they may prescribe. A majority shall be a quorum. They shall receive no compensation, but each shall be reimbursed his expenses actually and necessarily incurred in the performance of his official duties, out of such appropriation as may be made by the legislature. They shall choose from their number a president, secretary, and such other officers as their by-laws may prescribe; but no officer shall receive any compensation, except such as is herein provided for. The commissioners shall have general charge of the survey, and shall appoint a superintendent of the survey, and, on his nomination, such assistants and employees as they may deem necessary. They shall fix the compensation of all persons employed in the survey, and may remove them at pleasure.

SECTION 4. It shall be the duty of the commissioners to prepare a report before the meeting of each legislature, showing the progress and condition of the survey, giving an account of money spent, together with such other information as may be deemed necessary and useful. The superintendent shall transmit to the commissioners, from time to time, special reports, with necessary illustrations and maps, as these are com-

pleted. If approved by the commissioners, they shall be transmitted to the commissioners of public printing, who are authorized to have the reports published in a suitable manner, as independent reports, as bulletins of the state university, or in the transactions of the Wisconsin academy of sciences, arts, and letters, as the commissioners of the survey deem best. If published as independent reports, it shall be the duty of the commissioners of public printing to decide as to the number of copies in the edition of each particular report. Five copies of each report shall be delivered to each of the state officers, and to each member of the legislature. The number of copies provided by law for other public documents shall be furnished to the state historical society, the library of the state university, and other state institutions. The remainder of the independent reports shall be distributed, used in exchange, or sold by the commissioners of the survey, as the interest of the state and of science demands. All moneys obtained by the sale of the report shall revert to the state treasury, as a part of the general fund. Volumes obtained in exchange for the reports shall be added to the library of the Wisconsin academy of sciences, arts, and letters. The superintendent of public property shall furnish, upon the requisition of the president of the commissioners of the survey, such stationery and postage stamps as may be necessary for the use of the commissioners and the superintendent of the survey in official business.

SECTION 5. After material collected shall have served for the purposes of the survey, it shall be distributed to the state university, the colleges of state, the state normal schools, and the free high schools of the state, under the approval of the commissioners of the survey, in such a manner as to be of the greatest advantage to education in the state.

SECTION 6. There is hereby annually appropriated for two years to the commissioners of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of \$5,000, the first appropriation to be paid in the current fiscal year.

SECTION 7. This act shall take effect and be in force from and after its passage and publication.

Approved April 22, 1897.

CHAPTER 163, LAWS OF 1899.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of ten thousand dollars annually for the term of two years. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897.

SECTION 2. This act shall take effect and be in force, from and after its passage and publication.

Approved April 12, 1899.

CHAPTER 375, LAWS OF 1901.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

Section 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of five thousand dollars annually. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature.

Section 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 13, 1901.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

1. BULLETINS.

The publications of the Survey are issued as bulletins, which are numbered consecutively, and each bulletin is independently paged and indexed, no attempt being made to group them in volumes. The bulletins are issued in three series,

A. *Scientific Series*.—The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

B. *Economic Series*.—This series includes those bulletins whose interest is chiefly practical and economic.

C. *Educational Series*.—The bulletins of this series are primarily designed for use in the schools.

The following bulletins have been issued:

Bulletin No. I. Economic Series No. 1.

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. VI., 78; 1 map. Sent on receipt of 10c.

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. IV., 241; 14 plates, of which 2 are colored; 2 figures in the text. Sold at the price of \$1.50 in paper and \$2.00 bound.

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist Wisconsin Geological and Natural History Survey. 1898. Pp. IV., 63; 10 plates, 13 figures in the text. Sent on receipt of 10c.

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist Wisconsin Geological and Natural History Survey. 1898 (issued in 1899). Pp. XXVI., 544; 69 plates, of which 7 are colored, and 1 map. Sent to citizens of Wisconsin on receipt 30c; to others \$1.25.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region Around Devil's Lake and the Dunes of the Wisconsin, with some notes on its surface geology. K. L. M. D. S. S. R. A. M. Professor of Geography, Geology, University of Chicago, and Walter W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. X, 120. 25 cents. Bound in cloth. Sent on receipt of 25c.

Bulletin No. VI. Economic Series No. 5. Second Edition.

The Survey Report on the Copper Bearing Rocks of Douglas County, and parts of Washburn and Bayfield Counties, Wisconsin. C. C. S. and G. F. C. Professor of Geology, Northwestern University. 1901. Pp. VI, 38. 15 plates. Sent on receipt of 25c.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Brooks, Ph. D., Assistant Wisconsin Geologist and Natural History Survey. In charge of Economic Geology. 1901. Pp. XII, 204. 50 cents. Sent on receipt of 25c.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Penman, Ph. D., Professor of Geology, University of Colorado. 1902. Pp. XV, 178. 25 plates. 25 figures in the text. Sent bound on receipt of 25 cents.

2. BIENNIAL REPORTS.

The Survey has published three biennial reports, which relate to administrative affairs only and contain no scientific material.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1889. Pp. 3.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 3.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 3.

3. FORTHCOMING BULLETINS.

The following bulletins will soon be issued:

Bulletin No. IX. Economic Series No. 5.

Preliminary Survey of the Land and Water Region of Southwestern Wisconsin. U. S. Grant, Ph. D., Professor of Geology, Northwestern University. 1903.

Bulletin No. X. Economic Series No. 6.

The Soils and Flora Materials of Wisconsin. E. R. Buckley, Ph. D., State Geologist, Missouri, author of *Geology of Southeastern Wisconsin*, Geologic and Natural History Survey.

4. HYDROGRAPHIC MAPS.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S. Smith, Assistant Professor of Topographical Engineering, University of Wisconsin.

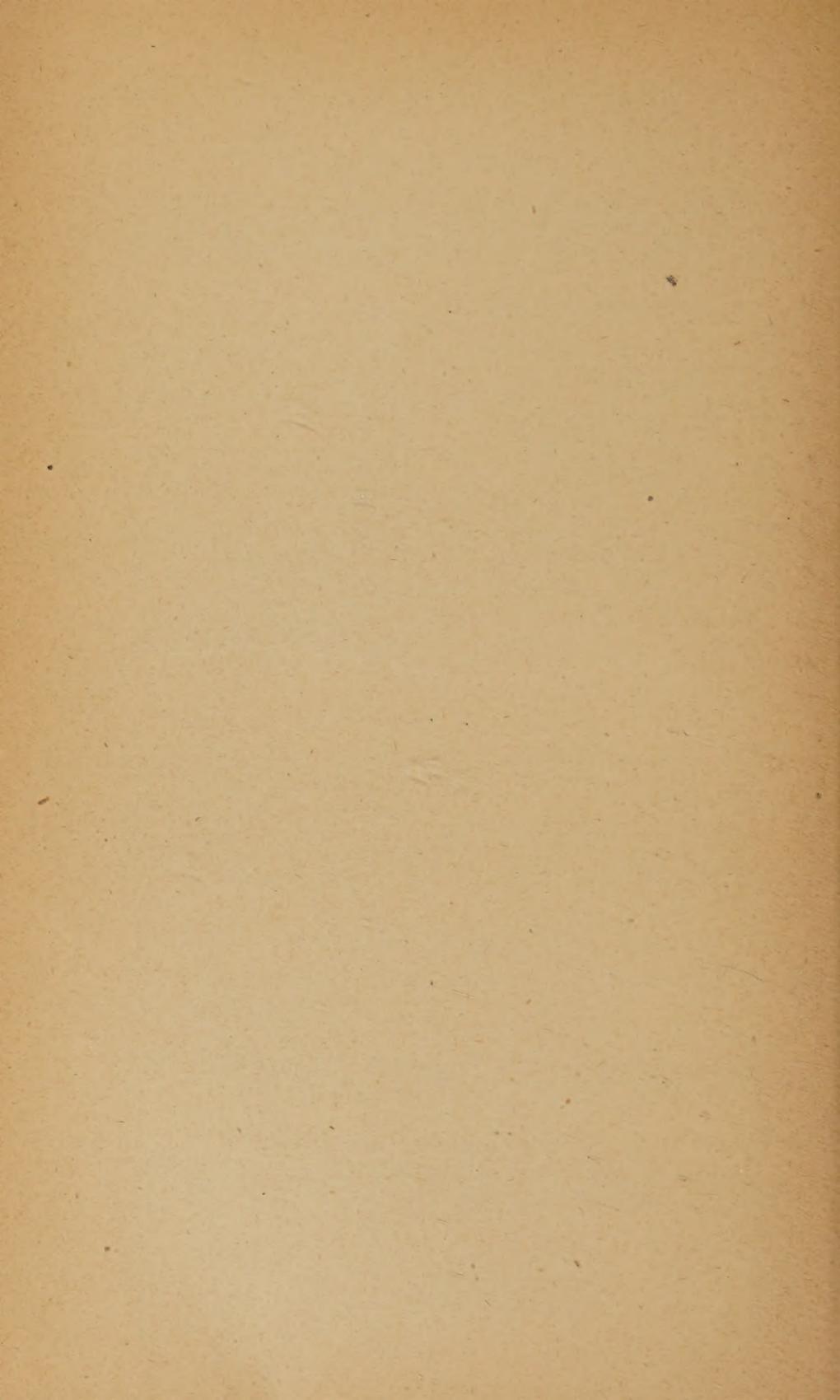
The following maps are now ready:

No.	Size of Plate, Inches.	Scale, Inches per mile.	Contour Interval, Feet.
No. 1.	Lake Geneva.....	17.5x10.8	2 10
No. 2.	Elkhart Lake.....	15.5x13.1	5 10
No. 3.	Lake Beulah.....	22.5x20.0	6 10
No. 4.	Oconomowoc-Waukesha Lake.....	29.8x19.1	2 10
No. 5.	The Chain of Lakes, Waupaca.....	21.7x20.8	6 10
No. 6.	Delavan and Landerdale Lakes.....	22.5x16.8	4 10
No. 7.	Green Lake.....	28.0x17.8	3.2* 20
No. 8.	Lake Mendota.....	23.7x19.5	6 5
No. 9.	Big Cedar Lake.....	18.0x13.5	2.9 10
No. 10.	Lake Monona.....	17.6x17.3	4 5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 15 cents each except Nos. 4 and 8, for which 20 cents are required. They may be had either mounted in a manilla cover, or unmounted.

All correspondence relating to the survey should be addressed to

E. A. BIRGE, *Director,*
Madison, Wis.



JOHN GARDNER
A HISTORY OF
SIXTY CHURCHES AND CHAPELS IN
THE COUNTY OF DURHAM